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Groundwater and Human Controls on the Suspended Sediment Load of Na Borges River, Mallorca (Spain)

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Groundwater dominance has important effects on the hydrological and geomorphological characteristics of river systems. Low suspended sediment concentrations and high water clarity are expected because significant inputs of sediment-free spring water dilute the suspended sediment generated by storms. However, in many Mediterranean temporary rivers, groundwater dominance is characterised by seasonal alternations of influent and effluent discharge involving significant variability on the sediment transport regimes. Such areas are often subject to soil and water conservation practices over the centuries that have reduced the sediment contribution from agricultural fields and favour subsurface flow to rivers. Moreover, urbanisation during the twentieth century has changed the catchment hydrology and altered basic river processes due to its 'flashy' regime. In this context, we monitored suspended sediment fluxes by means of three nested sub-catchments during a two-year period in the Na Borges River, a lowland agricultural catchment (319 km2) on the island of Mallorca (Balearic Islands) managed and therefore modified since Roman Age by agricultural soil and water conservation practices and recently by urbanisation. The suspended sediment concentration (SSC) was lower when the base flow index (i.e., relative proportion of baseflow compared to stormflow, BFI) was higher. Considering the high variability of the Mediterranean climate, a significant scatter of daily average SSC between sites and seasonally was observed, ranging between 22 to 54 mg l-1 for the total study period. The maximum instantaneous peak surpassed 6,000 mg l-1, recorded at downstream site based on the sediment supplied when there was no baseflow and the rainfall intensity was remarkable. At the other sites, peak concentrations did not exceed 2,000 mg l-1 because groundwater plays a more significant role. Furthermore, strong seasonal contrasts explain the high SSC coefficient of variation, which is clearly related to dilution effects associated with different groundwater and surface water seasonal interactions. A lack of correlation in the Q-SSC rating curves shows that factors other than discharge control sediment transport. As a result, at the event scale, multiple regressions illustrate that groundwater and surface water interactions are involved in the sedimentary response of flood events. In the winter, the stability of baseflow driven by groundwater contributions and agricultural and urban spills causes hydraulic variables (i.e., maximum discharge) to exert the most important control on events, whereas in the summer, it is necessary to accumulate important volumes of rainfall, creating a minimum of wet conditions in the catchment to activate hydrological pathways and deliver sediment to the drainage network. The BFI is also related to sediment delivery processes, as the loads are higher with lower BFI, corroborating the fact that most sediment movement is caused by stormflow and its related factors. Overall, suspended sediment yields were very low (i.e., <1 t km-2 yr-1) at all measuring sites. Such values are the consequence of the limited sediment delivery attributable to soil conservation practices, low surface runoff coefficients and specific geomorphic features of groundwater-dominated rivers, such as low drainage density, low gradient, steep valley walls and flat valley floors. Moreover, most sediment was transported in the wetter winter period when influent dynamics dominate along the drainage network. Strong contrasts are also evident between the three sites, revealing that significant sediment transport is accomplished in a shorter period for more ephemeral fluvial regimes.